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(54) METHOD FOR SCREENING FULL-LENGTH cDNA CLONES

(57) A method for efficiently screening full-length cDNA clones which comprises: determining the base sequence in the 5'-region of each clone contained in a cDNA library prepared by a method for constructing a cDNA library involving full-length ones at a high ratio; examining the presence/absence of initiation ATG in this 5'-region and the location thereof by using an originally developed software for anticipating initiation codons in cDNA; thus exactly judging the presence/absence of the initiation codon and the location thereof; and screening the cDNAs thus judged as carrying the initiation codon from the cDNA library. Moreover, a cDNA library containing full-length ones at an extremely high ratio can be constructed by mixing the clones thus selected above.

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Description

Technical field

[0001] The present invention belongs to the field of genetic engineering, and relates to a method for screening full-length cDNA clones.

Background Art

[0002] Recently, genome projects targeting various animals, plants, and microorganisms have been in progress. Numerous genes have been isolated and their functions are under investigation. In order to efficiently analyze the functions of isolated genes, it is important to efficiently obtain cDNA clones capable of expressing complete proteins, that is, full-length cDNA clones.

[0003] The followings are known as methods for constructing a full length-enriched cDNA library: the oligo capping method in which an RNA linker is enzymatically bound to Cap of mRNA (Sugano & Maruyama, Proteins, Nucleic Acids and Enzymes, 38: 476-481, 1993, Suzuki & Sugano, Proteins, Nucleic Acids and Enzymes, 41: 603-607, 1996, M. Maruyama and S. Sugano, Gene, 138, 171-174, 1994); the modified oligo capping method developed by combining the oligo capping method with Okayama-Berg method (S. Kato et al., Gene, 150, 243-250, 1994, Kato & Sekine, Unexamined Published Japanese Patent Application (JP-A) NO. Hei 6-153953, published June 3, 1994); and the linker chemical-binding method in which a DNA linker is bound to Cap (N. Merenkova and D. M. Edwards, WO 96/34981 Nov. 7, 1996), the cap chemical modification method by biotin modification of Cap (P. Carninci et al., Genomics, 37, 327-336, 1996, P. Carninci et al., DNA Research, 4, 61-66, 1997). These are all methods to modify Cap of eukaryotic mRNA and to prepare a full length-enriched cDNA library. A known method for constructing a full length-enriched cDNA library by trapping Cap is the method using Cap-binding proteins derived from yeast or Hela cells for labeling a 5'-cap site (I. Edery et al., MCB, 15, 3363-3371, 1995). Also known is Cap Finder (Clontech) that is the Cap Switch oligonucleotide method in which the Cap Switch oligonucleotide is annealed by C-tailing the 5' end of a first strand cDNA.

[0004] A cDNA library constructed by these methods is rich in full-length cDNAs compared to that obtained by the conventional methods. However, incomplete-length clones are also contained to some extent. To efficiently analyze the functions of genes and to efficiently clone novel useful genes, development of methods for easily confirming whether each clone contained in a cDNA library is full-length or not has been desired.

Disclosure of the Invention

[0005] An objective of the present invention is to provide a method for efficiently screening full-length cDNA clones, and a method for constructing a full length-enriched cDNA library.

[0006] The present inventors have studied to achieve the above objective and contemplated efficiently screening full-length cDNAs from a cDNA library by the presence or absence of a translation initiation codon as an index based on the fact that a cDNA deficient in a certain 5'-region is likely to lack a translation initiation codon, whereas a full-length cDNA contains an initiation codon. Especifically, the inventors assumed that a full-length cDNA could be efficiently screened from a cDNA library constructed by a method for preparing a full length-enriched cDNA library. Specifically, the inventors thought that full-length cDNA clones could be efficiently isolated by constructing a cDNA library by a method for preparing a full length-enriched cDNA library, determining several hundreds of base pairs of a DNA nucleotide sequence from the 5' end, and analyzing the presence or absence of an initiation codon in this region to screen the clones containing initiation codons.

[0007] However, few programs for predicting an initiation site of cDNA have been developed (e.g., "A. G. Pedersen, Proceedings of fifth international conference on intelligent systems for molecular biology, p226-233, 1997, held in Halkidiki, Greece, June 21-26, 1997). Though some programs for exons prediction have been developed ("Gene Finder". V. V. Solovyev et al., Nucleic Acids Res., 22, 5156-5163, 1994, "Grail" Y. Xu et al., Genet-Eng-N-Y., 16, 241-253, 1994), an initiation site cannot be accurately determined relying solely on these programs.

[0008] The present inventors have developed a program for cDNA initiation codon prediction by themselves and determined nucleotide sequences of the 5'-region of clones contained in a cDNA library constructed by a method for preparing a full length-enriched cDNA library to examine whether an initiation codon exists in this 5'-region using this software program.

[0009] More specifically, a full length-enriched cDNA library was constructed by the oligo capping method and nucleotide sequences of the 5'-regions of some clones contained in the cDNA library were determined. Based on the determined sequences, the clones were divided into known and novel ones through a database search. The presence or absence of an initiation codon and its location in the determined nucleotide sequences of the 5'-regions were judged using the initiation codon prediction program. For the known clones, whether the location of the initiation codon recog-

nized by the initiation codon prediction program coincides with that of the initiation codon in databases is examined. Indeed, the presence or absence and location of the initiation codon in the known clones predicted by the program coincided with the information in the databases.

[0010] Thus, the software program developed by the present inventors can accurately recognize the presence or absence of an initiation codon and its location, and full-length cDNA clones can be efficiently screened by selecting the clones that are recognized to contain an initiation codon by the program from the cDNA library. Moreover, a cDNA library extremely rich in full-length cDNAs can be constructed by combining the screened clones.

[0011] The present invention relates to a method for screening full-length cDNA clones from a cDNA library and a method for constructing a full-length cDNA library by combining cDNA clones screened by the screening method. More specifically, it relates to:

(1) A method for isolating a full-length cDNA clone, the method comprising:

(a) determining a nucleotide sequence from the 5'-region of a cDNA clone contained in a cDNA library,
(b) determining the presence or absence of an initiation codon in the nucleotide sequence determined in (a) using an initiation codon prediction program, and
(c) selecting clones recognized as containing the initiation codon in (b);

(2) The method of (1), wherein the cDNA library is constructed by a method for preparing a full length-enriched cDNA library;
(3) The method of (1), wherein a cDNA library is constructed by a method comprising a step of modifying Cap of mRNA;
(4) A method for constructing a full length cDNA library, the method comprising:

(a) determining a nucleotide sequence from the 5'-region of a cDNA clone contained in a cDNA library,
(b) determining the presence or absence of an initiation codon in the nucleotide sequence determined in (a) using an initiation codon prediction program,
(c) selecting clones recognized as containing the initiation codon in (b), and
(d) combining the clones selected in (c);

(5) The method of (4), wherein the cDNA library is prepared by a method for constructing a full length-enriched cDNA library;
(6) The method of (4), wherein the cDNA library is constructed by a method comprising a step of modifying Cap of mRNA; and
(7) A cDNA library obtainable by the method of (4).

[0012] The present invention is based on the inventors' findings that full-length cDNA clones can be efficiently isolated by analyzing nucleotide sequences of the 5-region of cDNAs in a cDNA library, specifically a full length-enriched cDNA library, by using a software program for accurately predicting a translation initiation codon, and a full length-enriched cDNA library can be constructed by combining the isolated cDNA clones. The method for screening full-length cDNA clones by the present invention comprises (a) determining a nucleotide sequence from the 5'-region of a cDNA clone contained in a cDNA library, (b) determining the presence or absence of an initiation codon in the determined nucleotide sequence using an initiation codon prediction program, and (c) selecting clones recognized as containing the initiation codon. The method for constructing a full-length cDNA library of the present invention comprises, in addition to above steps (a) to (c), step (d) of combining the screened clones.

[0013] In the method of the present invention, a "cDNA clone" whose nucleotide sequence of the 5'-region is to be determined is not particularly limited. Full-length cDNAs cannot be efficiently isolated from clones derived from a library not rich in full-length cDNAs, compared with clones derived from a full length-enriched cDNA library. Therefore, a cDNA clone is preferably derived from a library constructed by the above-described methods for preparing a full length-enriched cDNA library, including, for example, the oligo capping method in which an RNA linker is enzymatically bound to Cap of mRNA (Sugano & Maruyama, Proteins, Nucleic Acids and Enzymes, 38: 476-481, 1993, Suzuki & Sugano, Proteins, Nucleic Acids and Enzymes, 41: 603-607, 1996, M. Maruyama and S. Sugano, Gene, 138, 171-174, 1994), the modified oligo capping method developed by combining the oligo capping method with Okayama-Berg method (S. Kato et at, Gene, 150, 243-250, 1994, Kato & Sekine, JP-A-Hei 6-153953, June 3, 1994), the linker chemical-binding method in which a DNA linker is chemically bound to Cap (N. Merenkova and D. M. Edwards, WO 96/34981 Nov. 7, 1996), the Cap chemical modification method in which Cap is modified with biotin (P. Carninci et al., Genomics, 37, 327-336, 1996, P. Carninci et al., DNA Research, 4, 61-66, 1997), the method using Cap binding proteins drived from yeast or Hela cells (I. Edery et al, MCB, 15, 3363-3371, 1995), or a library prepared by Cap Finder using Cap Switch oligo-

nucleotide method.

[0014] A cDNA clone can be isolated from a cDNA library by standard methods described in, for example, J. Sambrook, E. F. Fritsch & T. Maniatis, Molecular Cloning, Second Edition, Cold Spring Harbor Laboratory Press, 1989.

[0015] A nucleotide sequence can be determined from the 5'-region of a clone by, for example, standard methods using DNA sequencing reagents and a DNA sequencer available from Applied Biosystems, etc. A whole nucleotide sequence of the clone dose not have to be determined, and determining about 1,000 nucleotides from the 5' end is sufficient. The high accuracy can be expected by determining about 500 nucleotides, even about 300 nucleotides.

[0016] An "initiation codon prediction program" used for analyzing a nucleotide sequence from the 5'-region of a clone is preferably the program developed by the present inventors as described in Example 1 below. The presence or absence of an initiation codon in a determined sequence is judged by a score deduced from the results of analysis with the program. A cDNA clone with a high score, recognized as containing an initiation codon in the determined sequence, is usually comprised of a full-length cDNA, while one with a low score, recognized as not containing an initiation codon in the determined sequence, contains an incomplete-length cDNA. Thus, a full-length cDNA can be efficiently isolated by screening a cDNA from a cDNA library, judged as containing an initiation codon in the nucleotide sequence. Indeed, in one embodiment of the analysis with the program described in Example 1 below where a cDNA library with the full-length cDNA content of 51% was used to screen clones (the highest score was 0.94), the content of full-length clones among the screened clones was 71% when clones showing a score of 0.5 or higher were selected, 77% with a score of 0.70 or higher, 81% with a score of 0.80 or higher, and 85% with a score of 0.90 or higher. Therefore, full-length cDNA clones can be screened with a high accuracy by selecting clones with high scores using the program described in Example 1.

[0017] Moreover, a cDNA library re-constructed by combining clones selected by the method for screening full-length cDNA clones of the present invention is extremely rich in full-length cDNAs compared with the parent cDNA library used for screening clones. By expressing whole cDNAs capable of expressing proteins in the thus-obtained library, a system for efficiently analyzing gene functions containing a mixture of expressed proteins can be obtained. This system enables efficiently cloning useful genes.

Best Mode for Carrying out the Invention

[0018] The present invention is illustrated in detail below with reference to the following examples, but is not to be construed as being limited thereto.

Example 1. Preparation of a program for predicting a translation initiation codon of cDNA

[0019] The translation initiation codon prediction program of the present invention recognizes a putative authentic initiation codon among all ATGs contained in a given cDNA sequence fragment. The program predicts based on A) information on similarity of given regions (several tens to several hundreds base pairs) at both sides of a putative ATG to translational regions and B) information on similarity of regions near a putative ATG to those near an authentic initiation codon. Characteristics of sequences in a translational region and regions near an initiation codon are extracted beforehand by from information of numerous sequences whose translational and non-translational regions have been identified. The program predicts an initiation codon based on the information about the above characteristics.

[0020] The linear discriminant analysis used in Gene Finder, a program for genomic exon prediction (Solovyev V. V., Salamov A. A., Lawrence C. B. Predicting internal exons by oligonucleotide composition and discriminant analysis of spliceable open reading frames. Nucleic. Acids Res, 1994, 22: 5156-63), was applied to optimize prediction. In the linear discriminant analysis, information on some characteristics derived from data is digitizied, weighted, and then culculated a score. Here, a score is converted into a probability of similarity to an initiation codon (the probability is a rate of correct answers obtained from data of sequences whose initiation codon has been identified). Specifically, a probability of similarity to an initiation codon of each ATG contained in a given cDNA sequence is output. Recognition as an initiation codon is determined whether a probability of similarity to an initiation codon is above a given threshold value or not. A threshold value is established depending on the plan of the following analyses, that is, depending on the extent of noises acceptable for the following analysis. For example, when 40% of noise is acceptable, a threshold value of 0.6 can be used. A parameter of weight is determined so as to maximize the prediction system using data of sequences whose initiation codon has been identified as a training datum. The above information of A) and B) were each embodied into the following three information and used as information about characteristics.

A) information on similarity of given regions (several tens to several hundreds base pairs) at both sides of a putative ATG to translational regions

[0021]

1: a frequency of six nucleotide base letters contained in a sequence from ATG to a stop codon (within 300 bp downstream of ATG at longest)
2: discrepancy of the information on a frequency of six nucleotide base letters contained in 50 nucleotide bases upstream and downstream of ATG
3: an index of similarity to a signal peptide [a hydrophobicity index of the most hydrophobic eight amino acids letters among 30 amino acids (90 nucleotide bases) downstream of ATG]

B) information on similarity of regions near a putative ATG to those near an authentic initiation codon

[0022]

1: information on a weighted matrix as using three nucleotide base letters in the region from 14 nucleotide bases upstream of ATG to 5 nucleotide bases downstream of ATG as a unit
2) the presence or absence of other ATGs upstream of ATG in a same frame (the presence is 1 and the absence is 0)
3: a frequency of cytosine contained in the region from 36 bases upstream of ATG to 7 bases downstream of ATG.

Example 2: Preparation of cDNA by the oligo capping method and analysis thereof by the program for initiation codon prediction

[0023] A cDNA library was prepared by the oligo capping method and the plasmid DNA was extracted from each clone by the standard method. Specifically, mRNA was extracted from human placenta and human cultured cells (Tetratocarcinoma NT-2 and neuroblatoma SK-N-MC) by the method described in the reference (J. Sambrook, E. F., Fritsch & T. Maniatis, Molecular Cloning, Second Edition, Cold Spring Harbor Laboratory Press, 1989). An oligo cap linker (SEQ ID NO. 1) with an oligo dT adaptor primer (SEQ ID NO. 2) in the case of Tables 1 & 2, or with a random adaptor primer (SEQ ID NO. 3) in the case of Tables 3 & 4 were subjected to BAP treatment, TAP treatment, RNA ligation, synthesis of a first strand cDNA, and removal of RNA according to the methods described in the references (Suzuki & Sugano, Proteins, Nucleic Acids, and Enzymes, 41, 603-607, 1996, p606, Y. Suzuki et al., Gene, 200, 149-156, 1997). The first strand cDNA was then converted into the double-stranded DNA by PCR, digested with *SFi*I, and cloned into vectors, such as pME18SCG, pMFL etc. digested with *Dra*III in the determined direction (Sugano & Maruyama, Proteins, Nucleic Acids, and Enzymes, 38, 472-481, 1993, p480). The obtained DNA was subjected to the sequencing reaction using a DNA sequencing reagent (DyeTerminatoir Cycle Sequencing FS Ready Reaction Kit, PE Applied Biosystems) following the manual and sequenced with a DNA sequencer (ABIPRISM 377, PE Applied Biosystems). The DNA sequence of the 5'-region of each clone was analyzed once.

[0024] The presence or absence of an initiation codon in the DNA sequence of each clone was analyzed using the developed program for cDNA initiation codon prediction (ATGpr). In this analyzing program, the higher the score is, the higher the probability of being an initiation codon is. The maximum score is 0.94.

(1) Analysis of translation initiation codons in the clones whose open reading frames are known in database among cDNA prepared by the oligo capping method

[0025] Among the results for all analyzed clones, the result for the clones that are known to contain the initiation codon in the determined sequences in databases (F-NT2RP1000020, F-NT2RP1000025, F-NT2RP1000039, and F-NT2RP1000046) are shown in Table 1. F-NT2RP1000020 (880 bp) has 96% identity at nucleotide positions 88 to 690 to "human neuron-specific gamma-2 enolase" (GenBank accession No. M22349); F-NT2RP1000025 (645 bp), 97% homology at positions 29 to 641 to "human alpha-tubulin mRNA" (GenBank accession No. K00558); F-NT2RP1000039 (820 bp), 96% identity at positions 12 to 820 to "human mRNA for elongation factor 1 alpha subunit (EF-1 alpha) (GenBank accession No. X03558); and F-NT2Rp1000046 (788 bp), 97% identity at positions 3-788 to "human M2-type pyruvate kinase mRNA" (GenBank accession No. M23725). The sequences of the 5'-region in these clones are shown in SEQ ID Nos: 4, 5, 6, and 7.

Table 1

	F-NT2RP1000020		F-NT2RP1000025		F-NT2RP1000039		F-NT2RP1000046	
ATG No.	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score
1	1	0.05	96	(0.94)	65	(0.90)	111	(0.94)
2	162	(0.84)	148	0.13	154	0.05	174	0.82
3	292	0.05	193	0.05	209	0.11	198	0.19
4	313	0.05	201	0.09	231	0.05	300	0.16
5	441	0.05	232	0.05	321	0.05	315	0.11

Note 1: ( ) means translation initiation codon
Note 2: Location of ATG means the nucleotide base position of ATG in the 5'-region of a DNA sequence.
ATG No. means the number of ATG from the 5'-region of a DNA sequence.

[0026] As show in Table 1, among the cDNA prepared by the oligo capping method, the full-length clones whose open reading frames are known in databases, containing initiation codons were accurately recognized by the initiation codon prediction program (ATGpr) (coincident with the initiation codons in databases).

(2) Analysis of initiation codons in the clones whose open reading frames are known in database among cDNA prepared by the oligo capping method

[0027] Among the results for the clones analyzed, the results for the clones whose initiation codon is known to absent in the determined sequence in databases (F-NT2RP1000013, F-NT2RP1000054, and F-NT2RP1000122) are shown in Table 2. F-NT2RP1000013 (608 bp) has 97% identity at positions 1 to 606 to "human nuclear matrix protein 55 (nmt55) mRNA" (GenBank accession No.U89867); F-NT2RP1000054 (869 bp), 96% identity at positions 1 to 869 to "human signal recognition particle (SRP54) mRNA" (GenBank accession No. U51920); and F-NT2RP1000122 (813 bp), 98% identity at positions 1 to 813 to *"H. sapiens* mRNA for 2-5A binding protein" (GenBank accession No. X76388). The sequences of the 5' region of these clones are shown in SEQ ID Nos: 8, 9, and 10.

Table 2

	F-NT2RP1000013		FNT2RP1000054		F-NT2RP1000122	
ATG No.	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score
1	21	0.05	31	0.12	23	0.07
2	27	0.05	60	0.20	100	0.05
3	32	0.32	87	0.05	166	0.05
4	56	0.11	97	0.05	235	0.06
5	119	0.10	146	0.05	316	0.05
6	125	0.08	172	0.05	346	0.05
7	141	0.05	180	0.11	406	0.05
8	155	0.06	218	0.07	431	0.05
9	161	0.06	272	0.05	469	0.06
10	176	0.08	319	0.07	546	0.12
11	203	0.07	346	0.05	553	0.05
12	290	0.20	363	0.07	574	0.05

Table 2 (continued)

	F-NT2RP1000013		FNT2RP1000054		F-NT2RP1000122	
ATG No.	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score
13	311	0.16	409	0.05		
14	314	0.12	480	0.07		

[0028] As shown in Table 2, among cDNA prepared by oligo capping method, the initiation codon prediction program (ATGpr) did not recognize by mistake the initiation codons in incomplete-length cDNAs whose open reading frames are known in databases and which do not contain any initiation codons.

(3) Analysis of initiation codons in novel clones among the cDNA prepared by the oligo capping method

[0029] Among the results for analyzed clones, the results for novel clones that were predicted to contain initiation codons (F-ZRV6C1000408, F-ZRV6C1000454, F-ZRV6C1000466, F-ZRV6C1000615, and F-ZRV6C1000670) are shown in Table 3. The sequences of the 5' region of these clones are shown in SEQ ID Nos: 11, 12, 13, 14, 15.

Table 3

	F-ZRV6C1000408		F-ZRV6C1000454		F-ZRV6C1000466	
ATG No.	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score
1	85	<0.94>	5	0.05	162	<0.86>
2	208	0.22	107	<0.87>	182	0.05
3	386	0.05	153	0.05	207	0.08
4	518	0.11	201	0.08	244	0.05
5	545	0.05	211	0.05	262	0.05
6			236	0.07	303	0.11

(cont'd)

Table 3 (cont'd)

	F-ZRV6C1000615		F-ZRV6C1000670	
ATG No.	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score
1	85	<0.94>	120	<0.94>
2	208	0.26	187	0.54
3	386	0.05	312	0.06
4	518	0.09	388	0.05
5	545	0.05	445	0.05

Note: <> means predicted initiation codon.

[0030] As shown in Table 3, the predicted initiation codons in F-ZRV6C1000408, F-ZRV6C1000454, F-ZRV6C1000466, F-ZRV6C1000615, and F-ZRV6C1000670 are "ATG" starting with "A" at positions 85, 107, 162, 85, and 120, respectively. Therefore, these clones were judged as full-length cDNA clones.

[0031] In addition, among the results for analyzed clones the results for novel clones predicted as not containing initiation codons (F-ZRV6C1001410, F-ZRV6C1001197, and F-ZRV6C1001472) are shown in Table 4. The sequences of the 5' region of these clones are shown in SEQ ID Nos: 16, 17 and 18.

Table 4

	F-ZRV6C1001410		F-ZRV6C1001197		F-ZRV6C1001472	
ATG No.	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score	Location of ATG	ATGpr Score
1	23	0.05	5	0.24	77	0.25
2	31	0.07	141	0.25	126	0.05
3	71	0.06	202	0.05	149	0.05
4	178	0.05	219	0.05	194	0.05
5	214	0.05	228	0.05	213	0.22
6					249	0.05
7					338	0.09
8					344	0.05
9					351	0.05
10					365	0.05

[0032] As shown in Table 4, F-ZRV6C1001410, F-ZRV6C1001197, and F-ZRV6C1001472 were recognized as not containing initiation codons. These clones were thus judged as incomplete-length clones.

Industrial Applicability

[0033] The present invention provides a method for efficiently selecting full-length cDNAs. Clones selected by the method of the present invention can express complete proteins. Therefore, the present invention enables efficiently analyzing the functions of isolated genes.

SEQUENCE LISTING

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<120> Method for screening full-length cDNA clones

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<150> JP 09-289982
<151> 1997-10-22

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GCCGCCACTG CCACTCCCGC TCTCTCAGCG CCGCCGTCGC CACCGCCACC GCCACTGCCA 120

CTACCACCGT CTGAGTCTGC AGTCCCGAGA TCCCAGCCAT CATGTCCATA GAGAAGATCT 180

GGGCCCGGGA GATCCTGGAC TCCCGCGGGA ACCCCACAGT GGAGGTGGAT CTCTATACTG 240

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CATATTTTAG ACTGAAAAAA TTTGCTGTTG CTGAATCTGA TTGTTATTTAN CANTTGCCT 660
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Claims

1. A method for isolating a full-length cDNA clone, the method comprising:

   (a) determining a nucleotide sequence from the 5'-region of a cDNA clone contained in a cDNA library;
   (b) determining the presence or absence of an initiation codon in the nucleotide sequence determined in (a) using an initiation codon prediction program; and
   (c) selecting clones recognized as containing the initiation codon in (b).

2. The method of claim 1, wherein the cDNA library is constructed by a method for preparing a full length-enriched cDNA library.

3. The method of claim 1, wherein a cDNA library is constructed by a method comprising a step of modifying Cap of mRNA.

4. A method for constructing a full length cDNA library, the method comprising:

   (a) determining a nucleotide sequence from the 5'-region of a cDNA clone contained in a cDNA library;
   (b) determining the presence or absence of an initiation codon in the nucleotide sequence determined in (a) using an initiation codon prediction program;
   (c) selecting clones recognized as containing the initiation codon in (b); and
   (d) combining the clones selected in (c).

5. The method of claim 4, wherein the cDNA library is prepared by a method for constructing a full length-enriched cDNA library.

6. The method of claim 4, wherein the cDNA library is constructed by a method comprising a step of modifying Cap of mRNA.

7. A cDNA library obtainable by the method of claim 4.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/04772

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl⁶ C12N15/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl⁶ C12N15/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
BIOSIS (DIALOG), WPI/L (DIALOG)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO, 94/08001, A1 (The Kanagawa Academy of Science), 14 April, 1994 (14. 04. 94) & JP, 6-153953, A & EP, 625572, A1	1-7
A	WO, 96/34981, A2 (GENSET), 7 November, 1996 (07. 11. 96) & EP, 824598, A2 & FR, 2733762, A1 & FR, 2733765, A1	1-7
A	Maruyama, K., et al., "Oligo-capping: a simple method to replace the cap structure of eukaryotic mRNAs with oligoribo-nucleotides", Gene, Vol. 138 (1994), p.171-174	1-7
A	Kato, S., et al., "Construction of a human full-length cDNA bank", Gene, Vol. 150 (1994), p.243-250	1-7
A	Carnincle, P., et al., "High-Efficiency Full-Length cDNA Cloning by Biotinylated CAP Trapper", (Genomics, Vol. 37 (1996), p.327-336	1-7

[x] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 January, 1999 (13. 01. 99)	26 January, 1999 (26. 01. 99)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP98/04772

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Edery, I., et al., "An Efficient Strategy To Isolate Full-Length cDNAs Based on an mRNA Cap Retention Procedure (CAPture)", Molecular and Cellular Biology, Vol. 15 (1995), p.3363-3371	1-7
A	Solovyev, V., et al., "Predicting internal exons by oligo-nucleotide composition and discriminant analysis of spliceable open reading frames", Nucleic Acids Research, Vol. 22 (1994), No. 24, p.5156-5163	1-7
A	Heindell, H.C., et al., "The Primary Sequence of Rabbit α-Globin mRNA", Cell, Vol. 15 (1978), p.43-54	1-7
A	Minoru Suzuki et al., "RT-PCR Process: Cloning of 5' end of mRNA by Oligocapping Procedure (in Japanese)", Protein, Nucleic Acid and Enzyme, Vol. 41, No. 5 (1996), p.603-607	1-7
A	Sumio Sugano et al., "Aiming at Full-length cDNA Library: Substitution of Capped Structure by Oligonucleotide (in Japanese)", Protein, Nucleic Acid and Enzyme, Vol. 38, No. 3 (1993), p.476-481	1-7
A	Carninci, P., et al., "High Efficiency Selection of Full-length cDNA by Improved Biotinylated Cap Trapper", DNA Research, Vol. 4, No. 1 (1997), p.61-66	1-7

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